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RAILWAY STATISTICS.

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A.

Analysis of Public Railway Statistics and Criticism of Such Statistics in the United States.

The following paper deals with the problem involved in getting and presenting to the public statistics of railways that will be intelligible and useful. Attention will be confined to steam roads or trunk lines, such new problems as are involved in the reports of express companies, pipe lines, water carriers, and the Pullman Company being untouched.

I. *The Grounds for Public Railway Statistics and the Bases for Statistical Units.*

The first approximation to a classification of the grounds for public statistics of railways would comprise the following subjects, all being matters in which it is now generally admitted that society through the government has a legitimate interest. (1) The adequacy of transportation. This resolves itself into two chief questions: (*a*) the adequacy of facilities such as track, equipment, and personnel; (*b*) the partly resulting adequacy of service, depending upon conveniences, speed, frequency, etc. (2) Closely connected with the general question of adequacy is that of safety of life and property. (3) The value of the transportation service, or the rate question, furnishes an important ground for statistics. Indeed the first points are in a sense subordinate to this and find expression in it; but the considerable extent to which rates depend upon adequacy of transportation should be emphasized: the railway machine is fundamental. (4) The value of the railway property, tangible and "intangible," forms a distinct but interrelated question, rates and taxation both being involved.

(5) Then there is the problem of sound finance, upon which certain statistics have a direct bearing,— a problem closely entwined with the preceding points. (6) And finally that part of the labor problem which lies in the field of transportation has a separate interest. The subjects of wages, hours, and condition of employment of railway labor have peculiar importance. This statement of the case is empirical and hardly analytical enough to be of the deepest value.

It is of some importance, in a more careful analysis of railway activities, to make the distinction between cost and service. For the public is primarily interested from the latter point of view; while in the case of the railway the private view point,— according to which the cost, or what may be called the net-revenue viewpoint, is the important thing,— is the one taken.

But service is not a simple matter. Accordingly it must be broken up into its elements to get at the bases for an adequate statistical statement. The various ideas embraced may be represented thus:

I. Service	1. Quantity	weight capacity		Unit of transportation-product.
	2. Utility	Speed Punctuality Frequency Direction Convenience Safety (Pass.) Commodity	Rate	
	3. Cost (including loss and damage perhaps.)			

Similarly the cost viewpoint must be analyzed:

II. Cost, or net revenue	1. Operation (gross)	" Performance " Expenditure	Units of expenditure and income.
	2. Traffic (net)	Revenue operations, or net or paying performance Income (especially net income)	

Finally there is the point of view of faculty—of "ability to pay" to society in the shape of taxes.

III. Faculty	1. Physical value	Way (including bridges, tunnels, etc.) Structures Equipment	Unit of value.
	2. Non-physical, or " intangible " value	Franchise Differential advantage of location: Negative (costs) Positive (earnings)	

As the reader may not have studied this phase of railway economics, a word of comment upon the above classification may not be amiss. As to the first or service viewpoint, it is obvious that the quantity of transportation product may be measured in either units of space or of weight. The car-mile unit is primarily one of space capacity, and only as goods are assumed to have like specific gravity does it serve as an index of weight service. This distinction as yet has its chief significance in the mail and passenger services.

It is evident that the utility of service, quantity remaining the same, varies according to speed, and certain branches of the freight service are differentiated on this basis. We have no statistics of the punctuality * and frequency of service, and but scanty ones concerning such elements as direction and commodity. To point to the significance of but two of these elements, take frequency and commodity. It is of considerable importance to know not only how many trains are run, but also how many are run in a given period of time, say 24 hours; and comparisons might be quite inadequate without information on this point. Above all, however, it is essential to know something of the proportions in which the various commodities enter into the transportation product. The *utility* of the service varies considerably as between sand and sugar or hay and packing-house products.

It will be observed that the rate is determined by the forces operating through utility and cost, and that the various factors in judging the utility of service are essential to judging the justice of the rate of compensation for service is apparent.

Then, at the end of the analysis of service, we must further observe that our unit of statistical judgment must be one which corresponds to service. If the transportation product which the railway furnishes society, and which is bought by the shipper, is the utility of moving so many pounds or tons from A to B, the ton-mile, not the car- or train-mile, must be the logical unit.

But meanwhile what of the cost viewpoint? In the first place the relation between the service and the cost viewpoints — the absence of an absolute barrier between public and private statistics — is to be mentioned. That locomotive performance, to be concrete, must vary with speed and direction; that frequency and convenience depend upon expenditure; that the cost to the shipper and the income of the carrier are related,—all these things are apparent. • As long as private ownership and operation exist there is a distinction. But to the extent that the government undertakes administrative control or seeks to enlighten the public on more fundamental points, to that extent, of course, the private aspect of the railway property is limited, or is "affected with a public interest." This is but another way of saying that the cost, or net-revenue viewpoint, is added to that of mere service. Here lies the connection between statistics and the rate problem.

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* The New York Public Service Commission compiles reports of number and percentage of trains on time and the average time late.

The distinction between operating and traffic statistics is one which, as such, is of small importance for the public. But in a general way it is important to keep statistics of net and gross load separate. In a sense, the "tare" weight is waste transportation, and society is justly interested in reducing the proportion of "dead" weight. It is the tendency with railways in this country to further develop traffic statistics, and it would be well if our public statistics were to profit by this development. This is notably true in the case of commodity statistics.

As in the case of service statistics we conclude by indicating that the logical statistical unit of judgment must be one which will vary with costs. To discuss such a unit in all its details would take us over into the field of purely private interest. But to the extent that this field is affected with a public interest, it is essential that our unit have a direct and logical connection with costs. As will be seen the train-mile must be criticised on this score.

II. *Criticism of the Present Situation.*

In what follows the position of looking for defects is frankly adopted, the various merits of the present statistics being taken for granted. To pass at once to an application of the above analysis, regarded as a statement of some of the essentials to complete statistics, the most obvious point to be made is deficiency of data on certain of these essentials.

1. *Omissions.* To the writer the capital omission seems to lie in the field of adequacy of facilities as limiting the quantity and the utility of the service, on the one hand, and increasing costs on the other. As will appear below, too, a most important factor in making statistics comparable is lacking here. One of the subjects on which special emphasis should be laid is the physical condition of the road proper,—the rail-way. As Mr. Byers in his *Economics of Railway Operation* says (p. 625) : " The question of operation with inadequate facilities is therefore one worthy of careful consideration, even from the standpoint of net earnings alone." The width of roadbed in part determines its bearing capacity ; upon the character and depth of ballast depend much of the stability of the track and the distribution of the weight of trains over adequate bearing surface, and the same may be said of the number and size of ties. If the rail is light it bends or waves, especially at joints, thus decreasing the load that an engine can haul. And the weight of rail varies from 50 lbs. to 100 lbs. per yard; the number of ties from 14 to 18 or more per rail (30 ft.); the depth of ballast under tie from 0 to 12 in. or more; and the width of roadbed from 12 ft. to 20 ft. These things affect engine performance, train-load, maintenance expenses, etc., directly and seriously. Also to make our train-, car-, engine-, and ton-mile units comparable we must know the conditions of this kind under which they were produced.

Then there are the matters of profile and allignment. That grades and curves affect directly and considerably both operation and maintenance, entering into the determination of net earnings and capital values, scarcely need be stated. The following data, to be found in the reports of European governments,—chiefly in Germany and Austria—are suggestive of our deficiencies on this score:

Railway Mileage :
  Average mileage for the year.
  Per cent. of double track.
  Miles used for $\left\{\begin{array}{l}\text{passenger service.}\\ \text{freight service.}\end{array}\right.$
  Miles in operation, under construction, to be constructed.

Physical Conditions.

- *Substructure:*
  - Miles of embankment.
  - Depth or height of cuts and fills.
  - Width of road bed (at base of rail).
  - Kind of ballast.
  - Cubic yards of ballast.
  - Grades and curves
    - number.
    - per cent. or radius.
  - Subways and culverts.
  - Tunnels
    - number.
    - total length.
    - clearance.
    - number of tracks.
  - Bridges and viaducts
    - number of tracks.
    - clearance groups.
    - total length.
  - Crossings, railroad, road, grade or not, kind of protection.
  - Junctions.

- *Superstructure:*
  - Ties and Sleepers
    - material.
    - number per mile.
    - treated or not.
    - price.
  - Rail
    - total weight.
    - weight per yard or mile.
  - Switches.
  - Telegraphs.
  - Signals, number of different kinds of signals, alarms, etc.
  - Buildings, number
    - stations, waiting rooms, administration buildings, shops, sheds, warehouses, water stations, coal chutes, treating plants, etc.
  - Turntables, moving platforms, loading devices.

Nor are these the only factors limiting train service. The length and frequency of passing tracks, in single track lines, is highly important; and, in a similar way, the frequency and capacity of water and coaling stations.

Other notable omissions are: statistics of condition of equipment; of speed, frequency, and punctuality of service (passenger); of commodities and kinds of traffic; of gross ton-miles; of locomotive-miles; of quantities and prices of materials consumed by railways; and of value of plant. Space is lacking for a discussion of all these deficiencies, nor are they of equal moment. Passing now to the matter of condition of equipment—where such data as *average* number, availability, number of seats, weight, etc., are missing, the following data, taken from statistical reports of European governments, will illustrate some shortcomings:

- I. *Motors :*
  - Kind
    - Tank locomotives, motor cars, electric locomotives and snow plows included.
    - Standard or narrow gauge.

- Number
  - *Average* number.
  - Number per 1,000 car-miles.
  - Number of coupled axes.
- Availability
  - Number placed in service each year.
  - Average locomotives in shop
    - Locomotive months.
    - Per cent. available.

II. *Cars:*

- 1. Freight
  - weight.
  - gauge.
- 2. Passenger
  - weight
    - total
    - average per seat.
  - guage.
  - heating.
  - number of seats
    - per car, by classes.
    - per mile track.
  - Cost
    - total.
    - per car;
    - per mile track.

Omitting from the present discussion the points bearing on character of service, which chiefly relate to passenger operations, we come to commodity and similar traffic questions. The Interstate Commerce Commission publishes a table on freight traffic movement which shows the *tonnage* of certain products of agriculture, animals, forests, and manufactures,* and further information is secured from the carriers but not published. But we should like to have the ton-miles, and, furthermore, should like to have these commodity ton-miles brought into relation with the revenue they yield. Nor is this mere academic curiosity. When a concrete problem in rates comes up the traffic manager must have such information; and the character of the argument in the Texas Cattle Raiser's Case is evidence of the importance of such information to the work of the Commission. It is virtually impossible to *compare* rates without an analysis of commodity movement and revenue. Also we feel the need of more information concerning quantity, utility, and perhaps cost, in the different classes of freight service; and more analysis of length of haul. To merely divide tonnage into the two groups, " originating on road " and " received from connecting roads," as does the Interstate Commerce Commission, leaves the question as to what tonnage and revenue are " local," what interline, or " through," without an answer. European statistics make information on the following points available, thus suggesting certain possible shortcomings in our figures, as the latter do not contain such information:

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* *Statistics of Railways in the United States*, 1907, p. 84.

Belgium: Movement of certain great classes of goods.
1. From and to various countries:
   Local } arriving; } long list—acids, asphalt, zinc, etc.
   Maritime } departing. }
2. Interior.
3. International:
   Germany, Austria, etc. (Chemicals, beer, lumber, etc.)

Italy: Tonage and income of principal commodities.
1. Importance:
   Tons
   Income
2. Quantity:
   Fast } grain, asphalt, etc.
   Slow
3. Income:
   Fast
   Slow

France:
Ton-miles { coal, coke, etc.
vehicles.
livestock.

Tons { grain; wine, vinegar, spirits; groceries and foodstuffs; cast iron, iron work, metals; raw materials (?) and manufactures; construction (building) materials; fertilizers; coal, coke and mineral fuel; miscellaneous merchandise; vehicles, horses, livestock (goods by piece and head).

Our passenger statistics are similarly inadequate, no analysis by classes being made. This will become more and more important as the volume of passenger traffic increases. Some typical units, taken from European reports, will serve to show what is possible in this line.

Passenger:
Number of passengers { per seat.
per mile track.
Number of passengers by price of ticket.
Total passenger income per car-mile.
Income per passenger by classes.
Income from first class, including special, excluding mileage.
Receipts from { Baggage.
Dogs.
Military and naval.
Special trains.
Milk on passenger trains.
Receipts from different classes of tickets:
   Round trip }
   Sunday } total; per cent.
   Laborers } per passenger.
   Excursion } per passenger mile.
   Mileage, etc. }

Lying more immediately in the field of operating statistics and the cost viewpoint, are the gross-tonnage and the locomotive-mile deficiencies. The former would be useful, as already indicated, in judging efficiency. The latter is needed to serve as a check upon the train-mile; for, as will appear shortly, the train may embrace varying numbers of locomotives, and furthermore light engine-mileage is an element in judging efficiency, absolute or relative.

Current discussions concerning the railways' "cost of living," etc., show the need of reliable price figures covering the most important materials used by railways, as well as wages. Such information is given in part by several foreign governments.

The value of plant is a more important question. Here foreign statistics indicate a backwardness on our part, though the different relations which exist between government and railways in part explain this fact. As the tide sets toward physical valuation and as such matters as depreciation accounts are used and made public, such statistics will become more necessary.* We now have the amount of operating expenses devoted to maintenance of way and structures, and to repairs and renewals of rails, ties, and equipment, and permanent improvements charged to income account; but nothing is shown concerning the extent or character of renewals, a matter of vital importance where a record of value of plant is concerned.

The following data are to be found in European reports:

Financial Statistics:
  Capital:
    I. Cost of buildings and plant.

Land and payment for use of land	Total, and per cent. per mile.
Fences	
Crossings	
Bridges	
Tunnels	
Permanent way	
Stations	
Shops	
Rolling stock, etc.	

- Expenditure connected with cost of buildings and plant.
  - Operating expense from building funds.
  - Interest during construction.
  - Loss through change in valuation.
  - Reserve and similar funds for amortization.
  - Other.
- Deductions.
  - Surplus from operation on building fund account.
  - Repayments not covered above.
  - Changes in valuation.
  - Expenditure from income and from funds set aside for amortization.
  - Subventions, etc.
  - Interest.

II. Capital realized from securities.
  Authorized { Stock.
  Authorized { Bonds.

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*See report of statistician in *Statistics of Railways in the United States,* 1907, pp. 147-8.

Issued $\left\{\begin{array}{l}\textbf{Stock.}\\ \textbf{Bonds.}\end{array}\right.$
Amount realized.
Remaining to be issued.
Retired.
Interest and dividend claims.
Guarantees $\left\{\begin{array}{l}\textbf{net income.}\\ \textbf{return on securities.}\end{array}\right.$
Subventions, etc.

2. *Illogical Units.* One of the most fascinating and important parts of the statistician's work is the development of the best units or bases of statistical judgment. On this side our published railway statistics compare favorably with any, but none seem above criticism. The principle of coherence is so commonly violated. To be true and logical the unit must be one based on a cause-and-effect relationship, that is, it must vary with the phenomena of whose summation it is an index, or must indicate the relation between worker and work done.

To illustrate this in a negative way take the much overworked train-mile. If it is to be our unit of service, simply as an index of utility rendered, it need only have the quality of varying in proportion to utility consumed by us. Or if it is to have a deeper significance, entering the rate question through the door of cost, it must meet the test of varying with costs, —of indicating the relation between tractive power (the worker) and tonnage movement (the work done). What is the result?

As to service one first reflects that the train is so lacking in homogeneity that the miles it makes are sadly lacking in uniform value. By the time one has asked how many cars there were in that train? what kind of cars—gondolas, box, tank, or stock? at what rate of speed did it move? was it going in the direction of prevailing traffic? was it a train of twenty years ago, made up of 30-ton wooden cars and drawn by a little "American-type" locomotive, or one of today with 50-ton steel cars and a Mallet locomotive?—by this time one finds that one train-mile is so different from another that he hesitates to accept it as a standard. Anyhow, he reflects, what one wants from the railway is not train-miles but tons (of goods) moved from A to B,—ton-miles, for short. And while, to be sure, there will be on the average some relation between trains and tons moved, it is not necessary or close enough.

This unit, however, is more often used as a cost index (see I. C. C. Statistics, 1907, pp. 396—498). But, passing over the difficulties of defining a train, it may be said that trains consist of one or more locomotives and a number of cars. In this compound aggregate some costs vary with the number and type of locomotives (wages of engine crew and say 30 per cent. of fuel), having no connection with the number of cars, or the " train." Others are peculiar to the cars. Finally there is a remainder that belongs to the train as such (balance of fuel, wages of train crew, etc.). Obviously the train-mile will serve as a homogeneous unit of cost only to the extent that the factors peculiar to locomotive expense and car expense are either negligible or capable of being averaged. Locomotive expenses are far from being negligible. Therefore the value of the train-mile unit partly depends upon an assumed average cost of locomotive-miles, having its weakness. As a unit of cost, perhaps the chief difficulty comes in the varying number and kind of locomotives embraced in the train. Then there are the varying " train resistances," depending on speed, number of cars, grades and curves, etc.

The theoretical lack of relation between train-miles and expense or performance is illustrated by the following relative figures:

Year.	Train-miles.	Average Cost per Train-mile.	Operating Expenses.	Ton-miles.
1897	100	100	100	100
1902	117	127	148	165
1907	146	158	232	242

To the writer it seems that the usefulness of the train-mile unit varies somewhat accordingly as it is applied to the passenger or the freight service,—suggesting, by the way, that the differences between freight and passenger service can not be removed through this agency. Considerations other than cost play so great a part in passenger operation that, from the last viewpoint, it has small importance; while in the freight service, if sufficient interpretative data concerning locomotive miles, gross and net tons per train, etc. are utilized, it may be of considerable service. From the service viewpoint the situation is reversed, for in the passenger service train-miles seem to approach more nearly a necessary relation to social service than in the freight service.* Considered as an independent unit the locomotive-mile is open to similar objections.

But without further elaboration the conclusion may be drawn that per-mile units have been too largely depended upon in our railway statistics. Phenomena which do not have a reasonably close relation to miles should not be measured in miles. We need more careful analysis of essential relations and variety of units each adapted to the particular case. A similar weakness might be illustrated from our accident statistics, where the *occasion* is made to serve as a *cause* in some columns.

Take the case of locomotive-miles. As a matter of fact locomotive-hours would mean more; for, taking all expenses connected with locomotive operation into consideration, it will be found that cost varies more with time than distance,—interest, certain repairs, fuel, etc. But hours alone can not measure locomotive performance: there must be some relation with product. What is produced is "draw-bar pull," or tractive power, so that to really judge efficiency of locomotives from either the cost or the service viewpoint a unit of tractive power must be used. Accordingly a recent report of the Committee on Conducting Freight Transportation of the Association of Transportation and Car Accounting Officers recommends the tractive-power-hour for use by the railways. Thus allowance would be made for different tractive powers, delays between terminals, etc.

Perhaps the true meaning of these different units appears most clearly when the railway is imagined as a great organism whose work is performed through a series of concomitant but subordinate activities. Each department has its function and its product, but that product may be the raw material for another department which carries the work a step farther,—perhaps to its consummation in the final transportation product. Thus in this hierarchy various units may be appropriate for various departments according to their contributions. If it is the function of the terminal force to move cars, "cars handled" is the appropriate unit—of cost, at least. Obviously the ton-mile is not a unit applicable to the work of the mechanical department; that department directly furnishes tractive power on the one hand and carrying capacity—cars, trains—on the other. And so on. The ton-mile caps the climax. But when one desires to judge the particular and peculiar efficiency of a subordinate part of the mechanism its peculiar work must determine its unit. Just as in the case of the cost viewpoint some question might be raised as to how far our government should go, so here it would be necessary to ask how intensive a regulation is desired to determine how many subordinate units are necessary.

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*As an index of service between particular points passenger train-miles may be of little value, as they would include trains which did not stop at one or both the points, perhaps, etc.

Not only is the per-mile average overworked, but also the simple arithmetic average is so used as to be a very relic of barbarism. It is hardly necessary to point out its limitations. As to the particular point now involved it fails in not indicating the weight and distribution of the factors averaged. Why, then, not make some practical use of such wellknown statistical devices as the weighted average, the mode, and the median? No average wage for all employes is given; a weighted average would be good. The mode would be best for the average trip and haul. Several shortcomings in the most used units of railway statistics might be capable of partial remedy by the adoption of more illuminating averages, if only the returns were made more analytically.

3. *Incomparability: lack of interpretative data.* A very unfortunate result of the above shortcomings in our statistics, and especially the omissions, is their lack of comparability, and on the need for greater comparability great emphasis should be laid. Most railway men will hold that it is impossible—or at least impracticable—to make truthful statistical comparisons of the operation of one division with another, of one railway with another, or the railways of one

country with those of another. The difficulty is certainly great, and in some cases doubtless insuperable. So numerous are the factors entering into operating conditions and the determination of rates, for example, that it would be extremely difficult to bring one set of conditions into contrast with another set and strike a balance. The various conditions can, with more or less difficulty, be ascertained and listed, but so complicated does the comparison then become that a comprehensive conclusion may not be possible, especially for the general reader. In spite of this fact, however, it is believed that at several points important steps may be taken toward making comparative statistics more illuminating. Much of the criticism of all statistics is due to the fact that they are lacking in comprehensiveness. Interpretative data should be brought into connection with them. In short, what is frequently needed is not the waste basket but *more* statistics,—to be used as memoranda.

Take, for example, the statistics of maintenance of way and structures expenditures. Here is a road which annually expends an average of 19 per cent. of its gross receipts for maintenance; there is another which expends an average of 30 per cent. One of the most important factors entering into the determination of the average difference is the character of the road bed, which may be fairly indicated by easily available statistics. Grades, curves, bridges, ballast, weight of rail, etc., should be known in order to judge as to the adequacy of expenditure for maintenance.

How adequate is the service rendered by one group of railways as compared with some other group? In one case there are no statistics as to frequency and speed of trains. Obviously an important factor must be omitted in any comparison.

Units expressing train load and train-mile density are important, but comparisons are relatively meaningless without the coordination of data as to character of road bed, frequency, and length of passing tracks, etc., all of which limit size and movement of trains.

The question of comparative rates is continually mooted, and in spite of the fact that exact and absolute comparisons are at present impossible, it would be a valuable step in advance if comparative statistics of real market value of listed securities, of physical characteristics of road and equipment, of proportions of local and through traffic, and more information concerning commodities, etc., were compiled. On this and the preceding paragraph what was said above concerning statistics of physical condition applies.

In this relation, and also bearing on the preceding points, the lack of separation of statistics of main and branch lines might be suggested as an important limitation upon comparability. Branch line traffic and branch line standards vary widely from those obtaining on main line, and the importance of keeping statistics of the two distinct is emphasized by the fact that several important roads do so, while most roads have the data easily available.

It would seem that the publication of such data in connection with statistics of receipts per ton per mile would serve to educate the public and keep to the front some realization of the intricacy of the problem, while enabling a rough and general appreciation of the factors which cause and warrant variations in ton- and passenger-mile earnings.

It is probably impossible at the present time to base rates entirely upon cost, and even a partial adoption of the cost basis must be more or less roughly approximate. Yet much remains to be accomplished in the way of cost accounting, and in any case the fairest way to approach this question is to first make available all pertinent information. It has been the writer's observation that practical railway men are more and more working toward an approximation of specific costs.

It is a common objection made by the carriers to furnishing statistical information that the data are only approximate and valuable to the railway for comparative purposes alone. It should be remembered that it is for just such purposes that government statistics possess their value. Careful approximations *made on the same basis* may be of the highest value, and it is for comparative purposes largely that statistics are compiled.*

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* Certainly it would be well to add notes warning the reader at points of the merely approximate character of the data.

B.

SOME SUGGESTIONS FOR THE IMPROVEMENT OF OUR PUBLIC RAILWAY STATISTICS.

In the first part of this paper the writer has essayed to lay the basis for an intelligent criticism of our public railway statistics. In what follows an attempt will be made to follow up the deficiencies above pointed out and to make certain concrete suggestions looking toward the improvement of such statistics. Accordingly, certain desirable additions to the information now available will first be indicated; then certain re-adjustments or new correlations, the use of more logical units of judgment, and aids to clear, forceful presentation will be suggested. Just as in the first part of this paper various units used in foreign reports were referred to as suggesting shortcomings, so in what follows reference will be made to data kept by American roads—but unused by the government as suggesting remedies.

The writer feels that he lacks the wisdom required to enable him to decide just what improvements are practicable when all their advantages are weighed against all their costs. Therefore, in what follows, he leaves it largely to more experienced minds to draw conclusions as to the relative expediency of the various courses suggested. His object is to point out what seem to him the most important *possibilities* for improvement.

I. *Additional Data.*

1. *Physical condition of roadbed, track, and structures.* There is no need to repeat the grounds for emphasizing the usefulness of statistics of roadbed, track, etc. The fact that knowledge or ignorance of one great part of the railway machine is involved makes a strong *prima facie* case. The further fact that such nations as Germany, Austria-Hungary, and Switzerland present such data is also noteworthy.

An illustration of the use made of such statistics appears in a statement of "Physical Characteristics of various Routes" between two points which was made recently by a certain railway at the request of financial interests, preliminary to supplying capital. The following data were embraced:

	Route 1.	Route 2.
Miles of:		
3.5 per cent. grade	....	....
3.4 per cent. grade	....	....
2.0 per cent. grade, etc	....	....
0.4 per cent. grade, etc	....	....
Equivalent miles of 1 per cent. grade	....	....
Ascents, east and west	....	....
Average grade per mile, east and west	....	....
Degrees of curvature, total and per mile	....	....
Maximum curve	....	....

In addition to these subjects data bearing on the passing-track situation are of considerable importance.

The following tables, then, are suggested as minimum requirements for any reasonable understanding of physical conditions. Concerning this table or group of tables it may be stated that the information is easily available, with the exception of actual amount and depth of ballast in some cases, and perhaps the character of rail in sidings. The items that seem least desirable have been bracketed. It is suggested that all lines having ballast under four inches in depth under tie be classed as unballasted. (It might be well to call between four and six inches " partly ballasted.")

CONDITION OF PERMANENT WAY.

Roadbed.			Ballast.						Ties.								
Width in Feet.			Ballasted.			Unballasted.	[Cu. yds. per mile.]	Av. depth under tie.	Standard size.		Average Number per Mile.						
Total.	Embankments.	Excavations.									Total.	Treated.			Untreated.		
			Stone.	Gravel.	Other.				Sawed.	Hewn.		Oak.	Other.	Pine.	Oak.	Other.	Pine.

Tie Plates.				Rails.										
				Main Track.								Side Track.		
				Steel.							Iron.			
Fully tie-plated (miles).	Partly tie-plated.		[Av. weight (lbs.).]	100 lbs. or over.	85-100 lbs.	75-84 lbs.	65-74 lbs.	50-64 lbs.	Under 50 lbs.	Av. wt.	[Av. wt.]	[Steel.]	[Iron.]	[Av. wt.]
	Miles.	No. per mile.		Miles.										

Track.								
Main Track.					Side Track.			
Single.	Double.	Triple.	Quadruple.	More.	Passing Tracks.			Other Sidings.
Miles.					Length (miles).	Av. Distance apart.	Av. Length (miles).	(Miles.)

GRADES AND CURVES.

Grades.															Curves.							Traffic Density.	
Level Line.		Line on Grade.												Average rise and fall per mile.	Straight Line.		Curved Line.					North and East.	South and West.
		North and East.						South and West.															
Mi.	%	.4-1%.	1-2%.	2-3%.	Over 3%.	Ruling Grade.		.4-1%.	1-2%.	2-3%.	Over 3%.	Ruling Grade.			Mi.	%	1°-5°	5°-10°	Over 10°.	Min. curve.	Av. degree curvature per mile.	Ton-miles (or train-miles) per mile, or loaded and empty car-miles.	Same as for N. and E.
						%	Length (yds.).					%	Length (yds.).										

It might be desirable to increase the number of degree-of-curvature and grade-per cent. groups, as do foreign governments. And the compensation of curves on ruling grades might well be included.* The preceding table, however, would seem fairly adequate. As indicated, several units of traffic density might be used, gross ton-miles per mile of line being probably the best. This, however, would involve some extra expense to the carriers,—though not a large one,—as tons and ton-miles are now generally thrown together regardless of direction. Inasmuch as the significance of distinguishing ascending and descending grades lies in unbalanced traffic movement, it is certainly desirable to bring some index of that movement into direct connection with statistics of grades and curves,—another illustration of the use of interpretative data.

Statistics of bridges, etc., might be supplemented by data concerning number of tracks, clearance, and the like. Also, railway engineers have suggested the desirability of recording the load capacity of bridges according to Cooper's Specifications, and of indicating type, whether plate girder or truss.

As limiting train service the frequency of coaling and water stations is of importance.

2. *Equipment.* On the subject of equipment: (1) more should be known concerning condition or availability; (2) there should be some unit of comparison between capacity of available rolling stock and traffic; (3) motor cars and electric locomotives might well be given special attention (motor cars being included with locomotives in European totals), and additions and new correlations bearing on these topics are recommended.

On the first point data are easily available. Availability of locomotives might be shown by distinguishing locomotives:

Total average number.
Available } In service
Available } Laid up in good order.
In shop.
Percentage available.

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*The ruling grade is generally the steepest grade on the road; it is the one which, by limiting the load which can be hauled by one locomotive, determines train-mile economies so far as grades are concerned. If there is a sharp curve on such a grade its effect is or may be very important, for it increases train resistances at a strategic point. A 6 degree curve on a 1 per cent. grade will make the grade as bad as a 1.3 per cent. one. To compensate for curvature is to cut down the grade on the curve, thus increasing the possible train-load, though perhaps adding to track mileage and total degrees of curvature.

Most roads classify power according to its need of repairs, as good, fair, poor, needing shopping. This is a matter of estimate. Repairs might be reported in this connection. Similarly information as to number of freight cars *available* would be significant. The average age of equipment would also have its importance.

On the second point, passengers and passenger-miles per passenger locomotive, tons and ton-miles per freight locomotive, and freight cars per 1,000,000 tons are shown at present: freight-car tonnage-capacity per ton-miles, or *number of cars of* 50 *tons capacity per*, say, 1,000,000 *ton-miles* would be more important in many ways. As to passenger cars, the number of cars or *number of seats per* 1,000,000 *passenger-miles* is suggested. From an operating standpoint the weight of passenger cars per locomotive or mile of track is used by our railways and foreign governments.

As some complaint has been made on the ground that the Federal Government makes unreasonable payment for mail cars,* it might be well to insert a separate item for such payments, say in the table on page 93 of the 1907 statistics.

3. *Locomotive Performance.* Locomotive performance is a subject upon which most roads have rather full and elaborate data, and concerning which foreign governments publish some statistics. Probably the railway companies would be inclined to regard such data as only of importance in a private way for operating officials. It does not seem essential that the public should know many of the details embraced in the various performance sheets, yet perhaps some proper and desirable information not now utilized lies in them. The tractive power of locomotives, and the ton- and passenger-miles produced are now shown; also total locomotive repairs and renewals, and cost of fuel, lubricants, and other supplies. In addition, for example, the various classes of locomotive-mileage might well appear, and certain averages of load and expense per locomotive-mile or per 1,000 ton-miles. Locomotive-miles, showing pusher- and helper-miles, might prevent a road from "jacking up" its train-miles. Locomotive-miles are,

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* And Hoff and Schwabach, in *Nord Amerikan Eisenb.*, criticise the government on this point.

perhaps, more important for comparison of maintenance expense, for instance, than train-miles. The first step to be taken toward making train-mile costs intelligible would be a reasonably analytical statement of locomotive-miles.

To these matters the highest importance is attached by most operating officials, and justly so; for the locomotive is the immediate source of power, and expenses connected with its operation form one of the large items of cost. Especially is the fuel consumption watched, the records of fuel consumed by individual locomotives often being quite accurate. Yet we can not even tell what the average fuel consumption per locomotive is.

4. *Service.* On the score of service the following data are used and are suggested as significant;

Number of trains during the year.
  Average number of trains per day { Freight / Passenger } Average cars per train to be shown in connection.
Train-miles per day.
  Train-miles per 1,000,000 population { Passenger. / Freight.
  Train-miles per mile of track { Passenger / Freight } During year, per day.
  Speed of trains (by class of service).

Certainly some index of speed and frequency of train service should be presented; and the use of the last three units is suggested. (The need for considering tons and cars per train should be pointed out by the statistician.)

5. *Prices of Materials.* The price of railway materials would seem to be an item which should be published, in spite of certain statistical difficulties. Justice can not be done to the constantly recurring argument that rates have fallen while expenses have risen by cursory "statistics" gotten up by interested parties nor by mere reference to growth of ton-miles and of low-grade traffic. The subject has real importance in regard to public policy towards such matters as renewals, maintenance, and rates. Perhaps prices of the following commodities would suffice:

Ties { Oak. / Pine.
Lumber, yellow pine.
Spikes.
Bar iron.
Steel rails.
Bridge materials { Girders. / Beams.
Car wheels.
Freight cars.
Locomotives.
Coal.

Of course the cars compared should be of the same capacity, and locomotives should be compared on the basis of a cost-of-tractive-power unit. An index number expressing the weighted average of such a list might be contrasted with index numbers of average receipts per ton per mile and traffic density.

6. *Renewals.* In connection with statistics of physical condition and of prices of materials the absence of information concerning renewals is recalled. The writer would strongly urge the collection of further data on this subject and their presentation together with those now collected but not presented. Such data should cover the character and extent of the renewal, the quantity of material used, and the expense incurred. This is largely done by some State commissions, *e. g.*, Wisconsin, and completely so by the foreign governments whose statistics are best (See *Statistik der Eisenbahnen Deutschlands*, 1907, Tabellen 9, 10, and 17). Not only should rails and ties be included, but ballast also. And some such record ought to be kept for equipment. It would be essential to the full value of the information that both the cost and the tangible result or product be included.

7. *Traffic Statistics.* On the subject of traffic statistics much might be said, but only the briefest treatment is possible. The great object, from the viewpoint of public statistics, is so to analyze and to separate different classes of traffic according to specific value, distance moved, speed and accommodation required, etc., as to make it possible to roughly interpret and compare receipts or rates and ascertain net service. In the case of passenger traffic it is recommended that passenger-miles and revenue be distinguished for several different classes of ticket or service. The following classification is inserted as illustrative of the idea:*

I. *Regular full fare*

1. Local
    - One way
    - Round trip
2. Interline
    - Home coupon
    - Foreign coupon

* The ordinary minimum data kept by the railways show: Local, Home Interline, Foreign Interline. Probably a majority make further subdivision.

II. *Special and reduced rates*

1. Mileage
2. Commutation and suburban
3. Half fare
4. Government
5. Excursion and homeseekers.

Also first and second class, and Pullman passengers might be separated.

Doubtless freight traffic statistics are at present far more important, though this is most true from the private viewpoint, in which the possibility of economizing decides, and here the question of commodity statistics at once arises. Railway men differ among themselves as to the importance of such statistics, and their practice both as to number of commodities distinguished and as to whether revenue is allocated to commodities, also differs. There can be no doubt, however, that the tendency is toward fuller commodity statistics. It is entirely possible that fear on the part of the carriers that undesirable conclusions—perhaps ignorant and hasty—concerning rates would be drawn from such statistics, rather than any belief in their lack of utility, has led them to refrain from making up these data or to conceal them when made up.

The Committee on Statistics of the Association of State Railway Commissioners has had the matter of commodity statistics under consideration, being actively engaged in ascertaining what commodities or groups of commodities are best. It would seem a considerable achievement if, in the various statements of tonnage and revenue, the statistician could distinguish: minerals, lumber, live stock, merchandise; also total car load, and total less-than-car-load.* The average tons per car, *loaded cars, and all cars*, should be shown.

One small road, recently investigated by the writer, kept separate record of 45 categories, showing tons only. These figures were made from agents' abstracts of way-bills received, without the use of cards, sorting, and tabulating machines. The larger roads used from 55 to 87 commodity categories, the one using 55 having in addition less than carload, emigrants' movables, other railroad material, construction material and miscellaneous (C. L.). This road used no machines and worked from the abstracts of way bills forwarded, first checking them with abstracts received. Three others used cards and machines.* Two of these punched the cards from agents' abstracts of waybills received, and one direct from waybills. These roads showed tons, ton-miles, earnings (or "rate") per ton per mile. Another gave tons by directions, and total revenue from the commodity.

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* From conversations in the field it would seem well for the government to put out a circular stating in some detail what commodities are to be placed in each class. This holds for the present situation.

Only one of the roads visited made a full analysis of tonnage and revenue as to " local " and " through ",—a road which otherwise had very scanty statistics. The Interstate Commerce Commission makes two groups: Originating on Road, and Received from connecting Roads. Each of these must be split in two to afford full information along this line: "Originating" freight (1) terminating on road, (2) terminating on other road; " Received" freight (1) terminating on road, (2) terminating on other road. Or all tonnage might be classed under these heads:

Interline	Originating Passing over Terminating
Local	

Some additional expense to carriers would be involved in the shape of clerk hire and the information would be of relatively slight importance to them. In fact, in regard to this last point, it is rather difficult to decide whether the information is of great enough importance to warrant putting the carriers to the expense of compiling it.

Still another helpful analysis would distinguish such classes of freight service as " dead " or " drag " freight and manifest, or " red ball," as to train- and ton-miles and revenue. Such information would be easily available from the records of most carriers.

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* At least two roads in addition to these use the Hollerith machines.

II. Readjustment and New Correlations.

1. *Personnel.* Something in the way of bringing number of employees into relation with a unit expressing the direct demand for their services would also be useful. The Interstate Commerce Commission gives number per mile of track and by different accounts. Why not show employees per 1,000,000 ton-miles, or

{ Employees on freight trains,
Freight trainmen and other employees, } per 1,000,000 ton-miles, and

{ Employees on passenger trains,
Passenger trainmen and other employees, } per 1,000,000 passenger-miles?*

In connection with the statistics of employees it is believed that information concerning pension, relief, and savings features would be of value. It would be of significance as bearing upon the total compensation received, and upon the general relation of employer to employee. The growth of pension and relief features has been rapid of late years.

2. *Separation of Main and Branch Lines.* In connection with the presentation of some of the foregoing statistics, as well as those already published, a point of no small importance is the separation of main and branch line statistics. One difficulty lies in the definition of the terms. As ordinarily used " main line " is that over which through trains are run, and generally through freight trains. Branch line would be the remainder, including " stubs " or feeders. To take some traffic-density basis for the distinction would rob it of a part of its significance, begging the question, as it were, in matters of comparison. On the other hand there would be some difficulty due to the fact that what some eastern trunk line would call branch-line on the through-train basis would be better than the " main line " of a small southern carrier, thus making such a wide variation as to rob the class of its significance. The difficulty might be met by subdividing through-

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* In presenting the data already at hand it would mean more to correlate work and workers rather than workers and line: Thus why not show employees " conducting transportation " per 1,000,000 train-miles? Maintenance of Way employees per 100 miles of *all track* would mean more than per mile of line; and Maintenance of Equipment employees per 1,000,000 car-miles would add something (p. 59, 1907 Report).

train main line into "Trunk" and "Other" for general purposes.*

3. *More Logical Units of Statistical Judgment.* In order to insure that the best units are referred to, it is necessary that the questions be asked, (1) is it logically related to service, to cost, or to both, as the case may be? (2) is it so put as to convey the most information? Especially on the former ground the train-mile must be severely criticised. It is suggested, then, that this unit must either be given up or some of its shortcomings must be remedied. In the first event a unit more logically connected primarily with service and secondarily with cost—which is a way of indicating the present relation of our government to the railways—must be substituted. Such a unit is the ton-mile, which for reasons indicated below, certainly is logically related to service—especially in the freight service—and it is believed that it is more closely related to cost than is the train-mile. But if the train-mile is to be retained—and it has its value—such interpretative data as locomotive-miles (by classes), tons (gross) per train, and grades and curves should be made readily available in parallel columns, foot notes, or elsewhere.

So with the locomotive-mile. We badly need some index of expense and tractive power, *i. e.*, net performance. The mile does not afford an adequate one. The hour is better, but taken alone is not good enough. There can now be no doubt that a unit of tractive power direct is practicable,—a unit equally applicable to cost or service. Considerable progress has been made along this line by the railways of this country, and just as the time is bound to come when coal will be generally sold on the basis of heat units contained, so it is logical to believe that the tractive-power unit will inevitably prevail. Trains are now made up on this basis. It has been recommended by practical railway men for general use,† and the writer found it in use on one large road which he recently investigated.

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* Main line is defined in the train rules of the American Railway Association as a track extending through yards and between stations, upon which trains are operated by time table, train orders, or the use of which is controlled by block signals.

† See Association of Transportation and Car Accounting Officers, Circular No. 83, released for publication, June 22, 1909.

It is the writer's conclusion that the ton-mile unit is the best available for general purposes, as in public railway statistics. It is the basic element in the final transportation product, measuring the quantity aspect. What society wants from the railway is place utility,—tons from A to B,—and if analyzed by commodities with other data as to utility available for interpretation such a unit serves well this purpose. Moreover it is as good as or better than any other unit for measuring costs. It will be immediately observed that by enumerating gross and net ton-miles the operating and traffic viewpoints are placed upon a common basis of measurement. In the freight service train-miles and train expenses correspond closely with gross ton-miles. The tractive power element is expressed in tons. And through these factors other classes of expense are related. Thus ton-mileage affords the best common denominator for measuring train- and station-service expenses. Again cost and service are best correlated on a ton-mile basis, and rates are, of course, made upon it.

Nor is the element of practicability to be overlooked. The ton is the natural unit of observation. The ton-mile is the basis of existing private statistics, operating and traffic. It is easily ascertained and checked; there is no difficulty in definition. The chief difficulties* lie in the lack of analysis as to commodity (on the utility side), and distance (on the cost side), both of which difficulties would be largely overcome by suggestions made above.

Several improvements may be made along the line of the criticism suggested by the second question. For example one sometimes wonders why no average wage for all employees is included in our report, and the first thought is to justify the omission on the ground that the average is of little value, even if not misleading, in such cases. But why not use the median—the middle wage in a series arranged according to magnitude? And quartiles and deciles would make the distribution clear. Or why not weight the average according to the number receiving the various rates or according to the expenditure for the group?

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*The varying percentage of terminal expense is a difficulty. A ton mile varies in cost accordingly as it is one of a few tons hauled many miles or many tons hauled few miles. But this could be minimized by classifying ton miles into distance groups as Belgium does. Or the time may come when cost of handling freight at stations may be available as a basis for deducting terminal expenses All large roads now have such figures for important stations.

Again, the average (arithmetic) haul per ton, average trip per passenger, and average capacity per car, etc., have not the meaning that the mode—the most common case—would have.* Here, however, as elsewhere, the difficulty lies in the additional time and expense of preparing analyzed figures. At present merely the total mileage or tonnage is reported and divided by the total number of tons, passengers, cars, etc.

Some steps have already been taken toward an analysis of freight traffic by commodities; but not until greater progress has been made along this line can a median or weighted average be substituted for the present average receipt per ton per mile, thus enabling us to allow for the effect of varying percentages of low-grade freight.

4. *Accidents.* These general deficiencies are to be noted: (1) certain desirable distinctions as to location of accidents, class of service, etc.; (2) the real *cause* of accidents as distinct from an *occasion* or description of its nature; (3) interpretive statistics of traffic density, all train accidents, etc. Under the first head might be mentioned: separation of passenger and freight service statistics; and of accidents at stations from those on other track. The second criticism is even more important. It should be possible to assign accidents among the classes: passenger's fault, employee's fault, faults of plant and material. And the last might be subdivided to show whether inherent or due to abnormal weather conditions. Collisions and derailments are not sufficiently classified as to nature and cause. To put collisions, derailments, parting of trains, in a table as co-ordinate, amounts to a cross classification: parting of trains results in collisions or derailments. And so collisions are due to running past signals; or derailments follow from broken rail, ties, etc.† For classifications of accidents which get down more nearly to causes, it is suggested that the statistics of England and

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* Belgium classifies tons and ton-miles by distance groups, *e.g.*, 1-10 km., 11-20 km., etc. (Railway statistics, 1907, p. 179, pt. A.)

† Cf., p. 136 of 1907 Interstate Commerce Commission Report.

Belgium be examined. To remove the validity of the third criticism it would be well to show ratios of fatal accidents to train-miles,—total, and passenger and freight,—passenger-miles, and miles of track. In the summary table for a series of years let the number of passengers appear and passenger-train and all-train miles. Doubtless, too, the number of train accidents in the passenger service, regardless of personal injuries, would be of value; for all these are potential fatalities and indicative of efficiency as to safety of service.

5. *Compilation and presentation.* Meanwhile the writer is aware that difficulties as to presentation in the shape of increased delay and space, etc. are thickening. In part he would escape obligation on this score by repeating that his main end is to criticise and suggest *possibilities.* But take the case of statistics of physical condition, for example. Here the data gain in value in proportion as they are made specific by presenting them for individual lines; and, so important does the information seem, that the addition of a new table to the already stout volume of Interstate Commerce statistics would seem desirable. It might be well, however, to present only such significant items as ruling grade, average rise and fall, sharpest curve, average degrees of curvature, average weight of rail, etc. in the extended table; while giving fuller details for a few important roads representative of each section.

In fact the scheme, used by England, of attempting certain important details for a group of large roads only, seems to be one which it is now time to utilize. Where (1) data can not be gained from many small roads, or (2) the time and trouble of enumeration would be too great, this might be done with profit; and it is the writer's opinion that such figures would mean much more than many now presented by the Interstate Commerce "groups."

As to the increase in traffic statistics, no new extended table would be involved, but two or three additional columns in existing tables and one or two new short general tables. Here again it is recommended that data be presented by typical individual roads or "systems."

If so practical and technical a suggestion might be hazarded, it would seem that the logical way to present increased tables would be to add to the size of the present volume, that is change it from octavo (6 x 9 in.) to quarto (say 9 x 11 in.). What is needed in many cases is more columns in order to give a more comprehensive and analytic view of the field covered by the table, and some modification in the direction of German statistics in this regard, is desirable.

With the new monthly bulletins of revenues and expenses and some slight adjustment in the customary "advance copy," no reason for fearing greater delay exists. No information has been suggested which railways do not make up.

On certain points there is a considerable lack of uniformity apparent in the classifications, definitions, and statistical bases used by the railways, and in such cases some ruling or recommendation should be made by the Commission, especially if additional data are to be asked for. Substantial uniformity in most matters now reported to the Commission is believed to exist, average daily wages and commodity statistics being the least satisfactory in this regard. But it is unfortunate in more than one way that any of the bases upon which interstate commerce statistics are made up should differ from those used in preparing similar data of the same name for private operating statistics. Such matters as gross tons per train, weight of empty cars, less-than-carload minimum weight, classification of repairs, and condition of equipment are lacking in uniformity of definition and compilation.

Doubtless some allowance must be made for time and place factors. The statistical compilations made by railways are continually changing, and not always in the direction of greater comprehensiveness of detail. From time to time officials of the same railway will call for some statement to meet a special need. This may even go on for a number of years through blind inertia. But it is not regular, standard information. Again the needs of one road may call for detailed statistics of some phase of operation or traffic, that would be useless or unprofitable to another. It may, in some cases, be a nice question as to whether the information is so important from the public point of view as to warrant putting those roads which would not otherwise made use of it to the expense of preparing it.